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The Role of Contingency Awareness in Affective Conditioning

정서의 조건형성에서 수반성 지각의 역할

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Abstract

Using the classical conditioning paradigm, we investigated the necessity of the conditioned stimulus-unconditioned stimulus (CS-US) contingency awareness for affective conditioning. An aversive sound stimulus was used as US, and sine wave gratings that varied in terms of the perceptual discriminability (high, low, control) were used as CS. The voluntary attention toward US (high, low) was also manipulated as between-subject condition. After the conditioning phase, the association between CS and US can be measured as the size of priming effect. Word evaluation task based on valence was used in Experiment 1, and lexical decision task was used in Experiment 2. When participants paid attention towards US, conditioned response was observed regardless of the CS discriminability. However, when subjects tried to ignore the US, conditioning occurred only if CS+ and CS- can be easily distinguished. The result provides support for dual-process model of conditioning.

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Chapter 1. Introduction

1.1. Study Background

Classical conditioning involves the association between a neutral stimulus and a certain stimulus that naturally elicits a biologically hard-wired response. After repeated presentation of the association, originally neutral stimulus evokes a learned response. The learned response is called conditioned response (CR) and the stimulus that yields CR is called conditioned stimulus (CS). On the other hand, the stimulus that yields the natural response is called unconditioned stimulus (UR) and the response is called unconditioned response (US). Pavlovian fear conditioning is showing fear response (CR) to originally neutral stimulus (CS) that is associated with threatening stimulus (US), which elicit fear response (UR) after repeated exposure to the association.

However, the existence of CS-US association alone is not sufficient to fully explain classical conditioning. There are constraints that determine the occurrence of affective conditioning. One of such boundary conditions is the contingency of CS-US presentation, which is defined in terms of likelihood (i.e., $\Delta P = P(US|CS) - P(US|\sim CS)$; (Allan, 1980). While most studies agreed upon that the contingency of CS-US relation is critical, whether contingency awareness is an enabling condition of associative learning has not reached consensus among researchers (Donahoe & Vegas, 2004; Lovibond & Shanks, 2002; Mitchell, De Houwer, & Lovibond, 2009; Murphy & Baker, 2004; Rescorla, 1988; Rescorla & Wagner, 1972). Mitchell, De Houwer, and Lovibond (2009) pointed out that the methodology implemented in previous studies on the issues had certain issues and bears invalid assumptions. In addition to this, theoretically, pure association view of associative learning cannot explain the characteristics of conditioning since mere association does not hold directional or relational information. In other words, the truth value regarding a

hypothetical relation between two stimuli can be assigned if and only if the relation is represented as proposition, which requires consciousness during the learning process (Mitchell et al., 2009). Besides to their main argument, Mitchell, De Houwer, and Lovibond (2009) made a logical suggestion that if one can provide instances of conditioning without the commitment of contingency awareness, it would be sufficient to claim that, at least, some cases of classical conditioning is based on pure association.

Yet, studies on this topic have come up with mixing results that support competing ideas respectively. For example, studies that have used explicit instruction to control contingency awareness or report from participants as contingency awareness criteria supported that not only the objective relation between CS and US, but also the awareness of such relation is important (Dawson, 1970; Dawson, Rissling, Schell, & Wilcox, 2007). In this context, learning the association between CS and US is attention-demanding process which is contingent upon the acquisition of explicit knowledge. On the other hand, other studies indicated yet another implication (Schultz & Helmstetter, 2010). Schultz and Helmstetter (2010) reported conditioning without awareness while the conscious knowledge regarding the association was controlled indirectly. Specifically, the researchers used differential conditioning paradigm with the discriminability of CSs being controlled according to one of the three conditions; easy, difficult, and control condition, and the easy discriminability group showed differently conditioned skin conductance response to CSs (Schultz & Helmstetter, 2010). In addition to this, research on patients with brain lesion demonstrated the double dissociation between conditioning and contingency awareness and suggested that classical conditioning is independent of declarative memory system (Bechara et al., 1995). However, the dual process theory of conditioning based on the independent existence of explicit and implicit level of processing that explains double dissociation of conditioning and contingency awareness (Bechara et al., 1995) failed to fit the data from other studies (Lovibond & Shanks, 2002).

1.2. Purpose of Research

Despite the abundancy of empirical studies, still, there is no conclusive argument on the issue. This is largely because the results from different studies cannot be compared directly due to methodological differences. Although classical conditioning has been thought to be about CS–US relation, it can be reinterpreted as CS–UR relation (Donahoe & Vegas, 2004) so that the controversial results might be due to the nature of response rather than classical conditioning itself. In addition to this, the dual–system approach does not exclude the influence of conscious knowledge. In other words, the evidence that supports the necessity of contingency awareness in associative learning does not necessarily refute the dual–system approach. Last but not least, there is no consensus on measuring awareness. This is an issue since propositional approach cannot account for affective conditioning without contingency awareness. As with what Lovibond and Shanks (2002) brought up, the validity of contingency awareness criteria can be questioned. This resulted in weakening the arguments on conditioning without contingency awareness. After reviewing evidence, Mitchell, De Houwer, and Lovibond (2009) maintained that only limited number of studies support unaware conditioning and concluded that associative learning is the result of conscious reasoning which requires contingency awareness.

It is in this vein that the current study tried to replicate conditioning without awareness and to explain the role that contingency awareness plays in classical conditioning. If classical conditioning is contingent upon the awareness of contingency information, there is no reason to assume the existence of implicit mechanism. Following this logic, studying whether the conditioning without awareness is possible or not is the only way to truly understand the structure behind associative learning. We hypothesized that contingency awareness plays secondary role in establishing classical conditioning. After the knowledge about the association between CS and US is acquired, expectation from the

knowledge is sufficient to elicit response regardless of the truth value of the proposition. Therefore, expecting the presentation of US can contribute to associative learning. In addition to this, we suggested that the vividness of US to be the main factor that determines the necessity of contingency awareness in associative learning. The study on secondary trauma report that, without direct access to stressful events, vivid vicarious experience can cause stress disorder (Jenkins & Baird, 2002; Way, VanDeusen, Martin, Applegate, & Jandle, 2004). This suggest that vividness is an important factor of fear learning. Moreover, there is a biological mechanism that shows increased response is crucial to associative learning (R. Hawkins, 1984; R. D. Hawkins, Abrams, Carew, & Kandel, 1983). Salient US tend to elicit more activation in presynaptic neuron, which further aids presynaptic facilitation and increase the duration of action potential (R. Hawkins, 1984; R. D. Hawkins et al., 1983). Therefore, US that can elicit strong response does not require the consistency awareness in classical conditioning in that subject can be conditioned through implicit process which dual-system theory proposes (Bechara et al., 1995). On the other hand, CS-US consistency awareness aids conditioning process explicitly.

Two experiments were conducted to test the role of CS-US contingency awareness in conditioning while manipulating the perceptual vividness of US. The structure was identical in both experiments. Differential fear conditioning on human subject was conducted using a pair of neutral visual stimuli as CS and unpleasant sound as US. That is, one of the CS signaled the presentation of US while the other served as a safety signal. The distinguishability of the specific type of visual stimuli that served as CS was measured and utilized to control the contingency awareness of individual participants. The vividness of US was controlled indirectly by controlling the level of attention that participants paid to US. This is because the interaction between contingency awareness and vividness is meaningful only if the physical characteristics of US remain the same across conditions. Thus, vividness is defined as

perceptual vividness of same stimulus instead of the physical intensity of same stimulus or perceptual vividness of different stimuli.

Chapter 2. Experiment 1

2.1. Method

Experiment 1 used differential conditioning with a pair of CSs of which discriminability was calibrated for individual participants (high discriminability, low discriminability, control condition). This was achieved via two-alternative forced choice (2AFC) discrimination task. Based on the result of 2AFC task, CSs were selected and used for visual detection task, which was performed during conditioning. One of the CSs was always associated with US (CS+) while the other was never paired with US (CS-) during conditioning phase. In addition, half of participants were instructed to attend to US because they serve as cue for target location (US attended). The other half of participants were asked to ignore US as it is irrelevant to the task (US ignored). Word evaluation task was used to measure conditioned response in terms of priming effect. This design allowed controlling the vividness of the US while the physical characteristics of the US remain the same across the conditions.

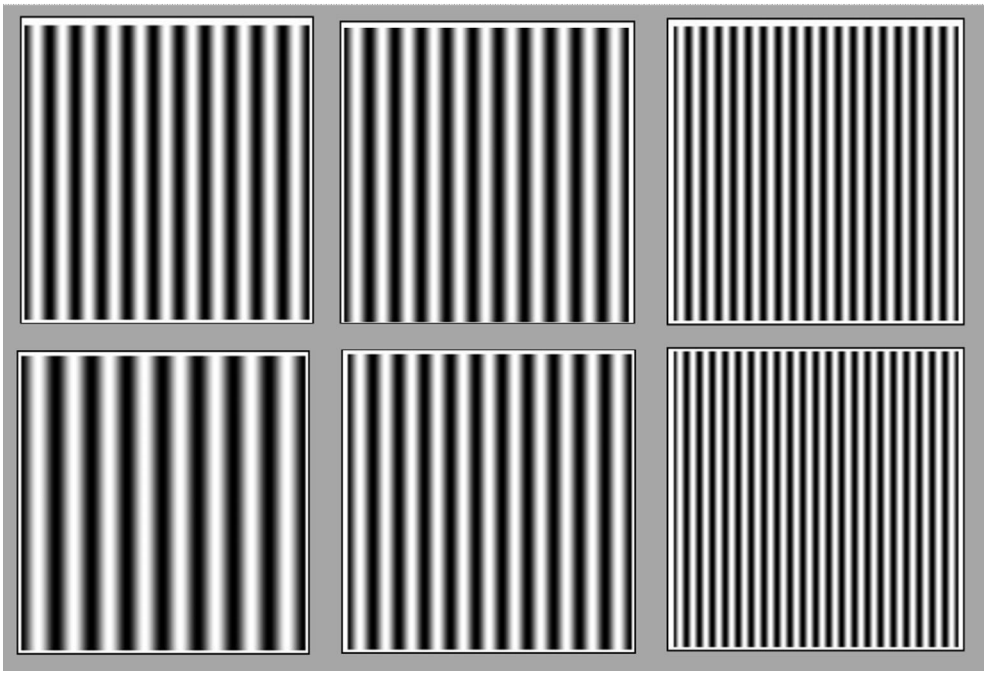
Participants were undergraduate in Seoul National University who were recruited through SNU-R Point system and offered course credit in introductory psychology classes. One hundred (53 females and 47 males) participants between the ages of 18 and 22 initially participated. Seventy-six (43 females and 33 males) participants aged between 18 and 22 finished the whole procedure.

For visual stimuli, 11 cm by 11 cm sine wave gratings that varied only in terms of the number of cycles were produced using Matlab software. The cycles of sine wave gratings ranged from 10 to 25 differed by 1. With 2AFC discrimination task on sequentially presented sine wave gratings, the distinguishability of the visual stimuli pairs was measured. With the result, the visual stimuli pairs that would serve as CS were chosen based on the experimental condition that the individual participant. Figure 1 shows examples. The criterion for indistinguishable sine wave gratings was 60% correctness condition in 2AFC task of discriminability. On the other

hand, distinguishable sine wave gratings pair was selected based on the 85% correctness performance in the same task. Finally, a randomly chosen sine wave grating was used as both CS+ and CS− for the control group.

<Figure 1> Examples of CSs for each discriminability condition.

High Discriminability Control Low Discriminability



Masking stimulus was 3.5 in. by 3.5 in. text slide filled with "#" in varying sizes. The target for visual detection task, which was performed during conditioning phase, was a black dot of 1 in. radius. All visual stimuli were presented on white background. The unpleasant sound that served as US for differential fear learning was the noise produced by scratching the blackboard with fingernails (Ely, 1975; Neumann & Waters, 2006; Neumann, Waters, & Westbury, 2008). If US were not to be presented, neutral sound of 440−Hz. sine wave tone was delivered. All auditory stimuli were delivered monaurally via headphone in a comforting volume level. For word evaluation task, 120 2−syllable Korean nouns were randomly chosen based on Korean emotional word list (Kim et al.,

2010). The procedure for measuring discriminability of sine wave gratings and word evaluation task was programmed and run on E-Prime 2.0 (Psychology Software Tools, Inc) on a Windows 10 PC with 23-inch monitor.

In both experiments, the 2AFC discrimination task on sine wave gratings were first given to all participants. In the discrimination task, participants had brief explanation on what sine wave gratings are. It was stressed that only the number of cycles matters for the task and the difference between stimuli will be small. Each trial begins with a fixation point on the screen. The fixation point remains for 1 s. As it disappears, the first stimulus slide appears for 700-ms. Following this is the masking screen presentation; the duration of which follows 100-ms to 300-ms uniform distribution. After the masking period, the second stimulus slide is presented for 700-ms. Then, the display remains blank until the participants make response. Participants were told to answer whether the sequentially presented sine wave gratings were identical or not. The identical condition trials were 10 times for each sine wave grating. On the other hand, the non-identical condition consisted of sequentially presented pair of sine wave gratings that are differed in 3 cycles and was set to 5 times for both higher and lower frequency gratings. Participants were told to report whether the pair of sine wave gratings are identical or not by pressing designated buttons. The task consisted of 4 blocks, and each block had 60 trials. It was preceded by 5 practice trials.

After 2AFC task, participants revisited the lab in a week for the second half of the experiment which included conditioning phase and assessment of conditioned response. During conditioning phase, participants were told to perform visual detection task. At the beginning of each trial, participants were exposed to the fixation mark at the center of display for 8 second to ensure keeping the influence of preceded trials from confounding following ones. Then, CS was presented on the screen for 1 second and disappeared. This was followed by auditory stimulus which lasted for 1 second and was delivered via headphone monoaurally. The auditory stimulus

was either US or a neutral one and had monaural quality. During the presentation of auditory stimulus masking image was displayed. As the presentation of the auditory stimulus ends, masking image was replaced by target screen. The location of the target was either left or right side of the screen 4 in. apart from the center of the screen. All participants were told that it is important not to make any eye movement and to response as quickly as possible by pressing the buttons indicating either left or right.

In addition to this, half of participants were told that the auditory stimulus served as the cue for the target location and were asked to attend to the location where the auditory stimulus indicated regardless of the type of the sound. The other half were told that the sound is non-predictive and might negatively influence their performance so that it is important to ignore the auditory stimulus. The former group was experimentally defined as the high vividness group, and the latter group is defined as the low vividness group.

Because differential conditioning was used for current study, 2 CSs were used; one of the CS was always associated with US (CS+) while the other was never paired with US (CS-). The performance of individual participants in 2AFC task was used to determine the pairs of sine wave gratings that served as CSs. For participants in high discriminability condition, one of the pairs that reached 85% correct response rate in 2AFC task was chosen randomly while 60% correct response rate in 2AFC task was the criteria for the CS pairs of the low discriminability condition. In both conditions, which sine wave gratings of the pair would be CS+ or CS- was determined randomly. On the other hand, a randomly chosen sine wave grating was used as both CS+ and CS- in control condition. The number of total trials was 126 of which 6 trials were practice trials in the beginning of the task. On practice trials, a randomly generated sinewave grating served as CS. Of the test trials, the ratio of trials with CS+ was 1/6.

A word evaluation task followed the visual detection task. Each trial began with the presentation of fixation. The fixation point

disappeared after 1 second and was followed by a 1 second CS presentation. Half of trials used CS+, and the other half used CS−. A 700ms masking display period separated CS from the presentation of target word. Half of target words were positive words while the other half were negative words. Participants were told to evaluate whether the given word is positive or negative as quickly as possible by making designated key press. Following 6 practice trials, 60 test trials measured the response time and accuracy of participant's performance.

2.2. Result

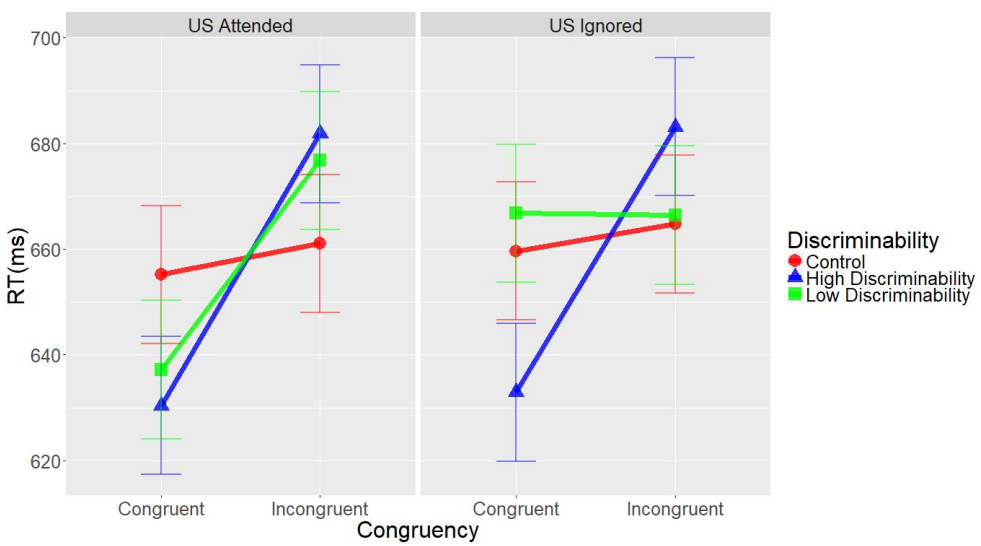
<Table 3> Result from Experiment 1

		Congruent	Incongruent
US Attended	High Discriminability (n=10)	630.37 (67.09)	681.85 (75.32)
	Low Discriminability (n=14)	637.19 (76.66)	676.81 (68.95)
	Control (n=14)	655.17 (41.78)	661.07 (58.41)
US Ignored	High Discriminability (n=13)	632.90 (46.05)	683.14 (85.03)
	Low Discriminability (n=13)	666.82 (73.99)	666.44 (74.63)
	Control (n=12)	659.65 (59.63)	664.76 (54.6)

To measure the effect of differential conditioning between different conditions, the result form word evaluation task was used. Specifically, of the trials with CS+, the difference between reaction time from correct response trials with negative target words (congruent trials) and those with positive target words (incongruent trials) was used. Outlying data points were excluded based on Tukey's test (Tukey, 1977). As a result, single data point was excluded. Table 1 shows the result.

As conditioned response was measured in terms of affective priming effect, reaction time for congruent trial should be shorter compared to that of incongruent trials. Thus, the congruency between the type of CS and the valence of the target word in word evaluation was expected to be significant if conditioning occurred. Furthermore, the interaction between discriminability and contingency was also expected to be significant because of the role played by contingency awareness in conditioning. Specifically, the absence of conditioning in participants without contingency awareness was expected to be observed. Finally, high level of vividness due to attention towards US was hypothesized to obviate the necessity of contingency awareness in affective conditioning. Therefore, it was expected that conditioning without contingency awareness should be observed if the US was attended showing significant interaction effect among congruency, discriminability and attention status.

<Figure 2> RT data from word evaluation task.



A type III repeated measure analysis of variance (ANOVA) was conducted with vividness manipulation (US attended, US ignored) and discriminability (high, control, low) as between-subject factors

and congruency (congruent, incongruent) as within-subject factor. This yielded significant main effect for congruency, $F(1, 70) = 14.24$, $p < .001$. There was also a significant discriminability by congruency interaction effect, $F(2, 70) = 4.85$, $p < .05$. However, all other main effects and interactions were non-significant. Especially, the predicted interaction among vividness, discriminability and congruency was not significant, $F(2, 70) = 1.26$, $p = .29$. Figure 2 shows the result.

In summary, Experiment 1 demonstrated the absence of conditioning for contingency unaware group which replicate previous studies on evaluative conditioning (Dawson, 1970; Dawson et al., 2007). The result indicated that conditioning occurred and successfully demonstrated in terms of affective priming effect. In addition to this, the conditioned behavior was more noticeable if the CS+ and CS- was easy to discriminate during conditioning phase. If CS is hard to discriminate, conditioned response was not statistically significant. Thus, there was significant influences of CS discriminability and CS-US relation on conditioning. On the other hand, the lack of significance in 3-way interaction requires further explanation. Specifically, taken into account the nature of the word evaluation task used in Experiment 1, it is conceivable that the 3-way interaction failing to reach statistical significance was due to task specific characteristics.

Chapter 3. Experiment 2

3.1. Method

Experiment 2 was conducted to replicate the trends in Experiment 1 with different task. The structure of both Experiments 1and 2 was 2 (CS-US relation, CS+ , CS-) * 3 (discriminability of CS; high, low, control) X 2 (vividness of US; US attended, US ignored). While word evaluation task was used to measure conditioned response in terms of response time in Experiment 1, lexical decision task was used in Experiment 2. This is because emotional state of participant (Niedenthal, Halberstadt, & Setterlund, 1997; Olafson & Ferraro, 2001).

Participants were undergraduate in Seoul National University who were recruited through SNU-R Point system and offered course credit in introductory psychology classes. Ninety-one (50 females and 41males) participants between the ages of 18 and 22 participated.

The same stimuli set was used for 2AFC discrimination task and visual detection task in Experiment 2 as in Experiment 1. For lexical decision task, 120 2-syllable Korean nouns were randomly chosen based on Korean emotional word list (Kim et al., 2010). For each word, a non-word was created by randomly replacing all vowels with other vowels. Experiment 2 was run in the same environment as Experiment 1.

The experimental procedure for Experiment 2 was overall the same as that of Experiment 1. However, instead of word evaluation task, lexical decision task was used to measure conditioned response. In lexical decision task, each trial began with the presentation of fixation. After 1 second the fixation point was replaced by a 1 second CS presentation. Half of trials used CS+, and the other half used CS-. A 700ms masking display period followed CS presentation. The target appeared as masking image disappears. The task contained an equal number of word and non-

word. Participants were instructed to press the ‘c’ key if they believe a word was presented and to press the ‘m’ key otherwise. Participants were told to respond as quickly as possible. Following 6 practice trials, 60 test trials measured the response time and accuracy of participant’s performance.

3.2. Result

<Table 2> Result from Experiment 2

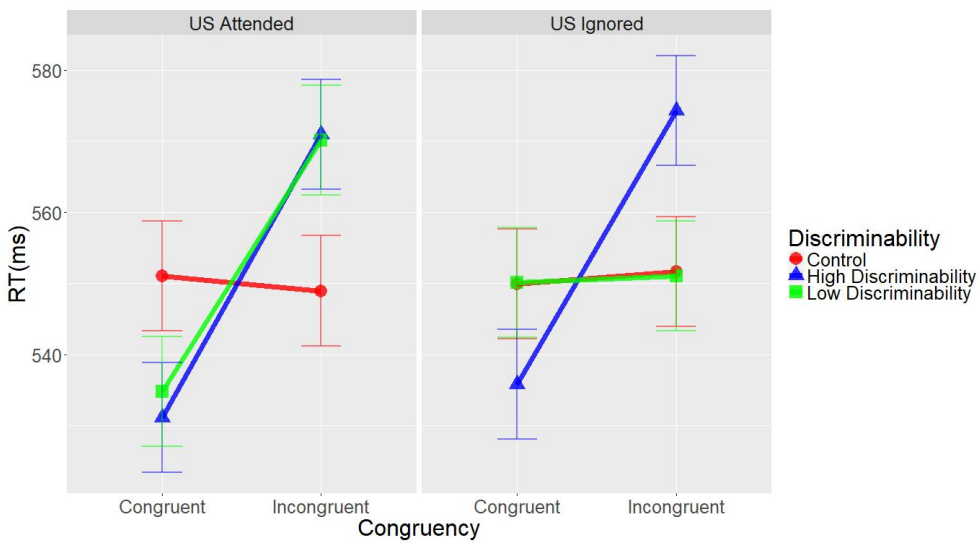
		Congruent	Incongruent
US Attended	High Discriminability (n=16)	531.07 (50.23)	570.95 (43.96)
	Low Discriminability (n=16)	534.8 (45.95)	570.13 (34.41)
	Control (n=16)	551.02 (55.86)	548.94 (62.83)
US Ignored	High Discriminability (n=14)	535.81 (69.92)	574.28 (78.29)
	Low Discriminability (n=14)	550.16 (58.28)	551.04 (66.31)
	Control (n=15)	549.91 (37.08)	551.62 (41.07)

Because Experiment 2 shared the same logic with Experiment 1, the effect of differential conditioning between different conditions was measured in terms of priming effect. Because of the shared logic and design, the main effect of congruency was expected to be significant. A significant discriminability by congruency interaction effect was also expected. Finally, the interaction among vividness, discriminability and congruency was also expected to be significant. As with Experiment 1, outlying data points were excluded based on Tukey's test (Tukey, 1977). No data point was excluded. Figure 3

shows the result.

A type III repeated measure analysis of variance (ANOVA) was conducted with vividness (US attended, US ignored) and discriminability (high, control, low) as between-subject factors and congruency (congruent, incongruent) as within-subject factor. This yielded a significant main effect for congruency, $F(1, 85) = 35.81$, $p < .001$. There was also a significant discriminability by congruency interaction effect, $F(2, 85) = 12.85$, $p < .001$. Last but not least, the predicted interaction among vividness, discriminability and congruency was significant, $F(2, 85) = 3.53$, $p < .05$. All other main effects and interactions were non-significant.

<Figure 3> RT data from lexical decision task.



Experiment 2 replicated priming effect and absence of conditioning under contingency unawareness, which were observed in Experiment 1. However, in Experiment 2, conditioning occurred in both high and low CS discriminability conditions provided that the vividness of US was high. That is, the significance of 3-way interaction indicated that contingency awareness is not essential part of affective conditioning.

Chapter 4. Discussion

The current research is to resolve the debate over the necessity of contingency awareness in affective conditioning and to explain contradictory results from different studies. Under the assumption that the acquisition of contingency awareness produces expectation-driven response, it was hypothesized that conditioning without awareness would be observed if US itself elicits strong UR. That is, the interaction between the contingency awareness and the vividness of US determines whether conditioning occurs or not.

In both experiments, differential conditioning paradigm was used for affective conditioning. CS+ was always associated with US while CS- was never associated with US. The discriminability of CSs was calibrated for each participant. If CSs were easy to be discerned, participants were likely to be aware of the contingency between CS+ and US. If CSs were hard to distinguish, any proposition regarding the CSs-US relation cannot be verified surely. The perceptual vividness of US was manipulated indirectly via instruction rather than changing physical parameters of US. This was because the hypothesis cannot be tested in a valid manner without keeping physical characteristics of US the same across experimental conditions. Conditioning effect was measured in terms of priming effect.

Experiment 1 confirmed the absence of conditioning for unaware participants. Although the expected 3-way interaction did not reach statistical significance, the data indicated that the result was due to task specific characteristics. In this vein, Experiment 2 was conducted. Experiment 2 was to mainly replicate the observed trends in Experiment 1 with different task. In Experiment 2, the interaction between discriminability and congruency was significant as in Experiment 1 implying the role of contingency awareness in conditioning. However, the statistical significance of 3-way interaction indicated that conditioning without awareness occurred if

participants were exposed to perceptually salient US.

In examining the role of the contingency awareness in classical conditioning, the current study introduced vividness of experience and demonstrated the absence and the existence of conditioning without awareness. The results showed in which case the role of contingency awareness is marginal and supported the dual-system theory of conditioning. The current study found that the vividness of US determines whether contingency awareness is necessary for successful conditioning. This provides probable explanation for contradicting results of previous studies. For example, while Dawson and colleagues (2007) reported that contingency awareness is essential factor in evaluative conditioning, Schultz and Helmstetter (2010) showed that conditioning had occurred without explicit knowledge about contingency. The critical difference between these contradicting results is that while Dawson and colleagues (2007) used pictures as US and made conditioning process implicit, Schultz and Helmstetter (2010) used electrical stimulus and subjects were informed of conditioning. Thus, those who participated in the latter were likely to exposed to vivid experience both in terms of stimulus characteristics and the nature of experience itself.

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국문초록

정서적 조건형성 맥락에서 살펴본 수반성의 역할

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고전적 조건형성 패러다임 하에서 조건자극과 무조건자극 사이의 수반성이 정서의 조건형성에 필수적인지 연구되었다. 불쾌한 소리가 무조건자극으로, 지각적 구분용이성 수준에서 차이가 나는 사인파 격자 쌍이 조건자극으로 사용되었다. 무조건자극에 참여자가 주의를 기울이는지의 여부를 통제함으로써 무조건자극의 생생함이 참여자 간 변인으로 조작되었다. 조건형성 후 조건자극과 무조건 자극 사이의 연합은 프라이밍 효과의 크기로 측정되었다. 실험 1에서 이는 단어 정서가 평정 과제의 맥락에서 측정되었으며 실험 2에서는 어휘판단과제의 맥락에서 측정되었다. 참여자가 무조건자극에 주의를 기울인 경우 조건자극의 구분 용이성과 무관하게 조건형성이 일어남이 관찰되었다. 그러나 참여자가 무조건자극을 무시하는 경우 조건자극 간 구분이 쉬운 경우에만 조건형성이 관찰되었다. 이 결과는 조건형성의 이중절차 이론을 지지한다.

keywords : 정서의 조건형성, 수반성 지각

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